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EVALUATION OF THE EFFECTIVENESS OF STRUCTURAL CALCULATION FOR THE ISLAMIC AMINAH HOSPITAL BUILDING USING PROFESSIONAL STRUCTURAL ANALYSIS ROBOT APPLICATION

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ABSTRACT

The building structure plays a crucial role in ensuring the safety, comfort, and resilience of buildings, especially in earthquake-prone areas like Indonesia. This study aims to evaluate the effectiveness of structural calculations in the construction of the Aminah Islamic Hospital building in Blitar City using Robot Structural Analysis Professional software. The structural calculations refer to the Indonesian National Standards, namely SNI 2847:2019 for reinforced concrete structures, SNI 1726:2019 for earthquake resistance planning, and SNI 1727:2020 for minimum loading. The focus of the study is limited to the upper structure, including column and beam elements. The evaluation results show that the building structure is designed effectively and meets the criteria for strength and earthquake resistance according to applicable standards. The use of this software is assessed to enhance accuracy and efficiency in the structural planning process. This research is expected to serve as a reference in the planning and design of multi-storey buildings, especially health facility buildings, so that it can provide optimal protection for building users.

Keywords: Reinforced concrete structure, Robot Structural Analysis, SNI 2847:2019, SNI 1726:2019, hospital, structural analysis.

Introduction

The building structure is a system composed of a series of structural components designed to safely bear and transfer loads into the ground. Understanding building structures is very important in planning and construction to ensure the safety, comfort, and durability of the building. Structures generally consist of two parts: the substructure, or the structure located below the ground surface, such as foundations, and the superstructure, or the structure located above the ground surface, such as columns, beams, and slabs (Sijabat et al, 2021).

Live load is a significant burden and its position can vary. This load includes the weight of humans, movable furniture, vehicles, and other items that frequently change locations, thereby causing alterations in the load on the floor and roof. Specifically, for roofs, live loads can include loads from rainwater, whether due to pooling or from the impact of falling raindrops. Live loads do not include wind loads, seismic loads, or special loads. The definition of live load according to article 4.1 of SNI 1727 of 2020 is the load caused by users and occupants of a building or other structure that does not include structural loads and environmental loads (Indonesian Standardization Agency, 2020).

The Earthquake Load is all equivalent static loads acting on a building or part of a building that mimic the effects of ground motion due to the earthquake. In the case where the influence of the earthquake on the building structure is determined based on a dynamic analysis, what is meant by earthquake load here are the forces within that structure caused by the ground motion due to the earthquake (Sijabat et al, 2021).

Indonesia is located at the meeting point of three tectonic plates: the Indo-Australian Plate, the Eurasian Plate, and the Pacific Plate, thus situated in the Pacific Ring of Fire. The Pacific Ring of Fire is a region that stretches approximately 40,250 kilometers around the Pacific Ocean. The shape of the Pacific Ring of Fire resembles a horseshoe rather than a circle. (Raihan Daffa Hukama, Erizal, 2023).

In 2021, the Blitar Regency experienced an earthquake with a magnitude of 5.9 on the Richter scale. The epicenter of the earthquake was located at coordinates 8.63° S and 112.34° E, or precisely in the sea at a distance of 57 km southeast of Blitar Regency, East Java, at a depth of 110 km. The impact of the earthquake caused buildings to sustain light, moderate, and severe damage, and this earthquake was caused by the subduction of the Indo-Australian Plate beneath the Eurasian Plate at a rate of about 7 cm per year to the north. For this reason, buildings located in the Pacific Ring of Fire must meet earthquake-resistant building standards (BMKG).

The calculation of reinforced concrete structures in Indonesia uses the reference of the Indonesian National Standard (SNI). There are several references that can be used in the calculation of structures in Indonesia, one of which is SNI 2847 – 2019 and SNI 1726 – 2019 regarding earthquake resistance planning for building and non-building structures. In this case, what needs to be calculated are the reinforced concrete elements (foundations, columns, beams, and slabs). Load calculations must use the regulations stated in SNI 1727-2020 concerning Minimum Loads for Structural and Non-Structural Building Planning.

The use of the Robot Structural Analysis Professional application, a structural analysis and design software based on the Finite Element Method developed by Autodesk and widely used in the design of multi-story buildings. This software is capable of analyzing the detailed behavior of structures under various types of loads, including gravitational loads, lateral loads such as earthquakes and wind, as well as complex load combinations that often occur in tall buildings. RSAP supports both linear and non-linear analysis and can model structural elements such as beams, columns, floor slabs, and shear walls.

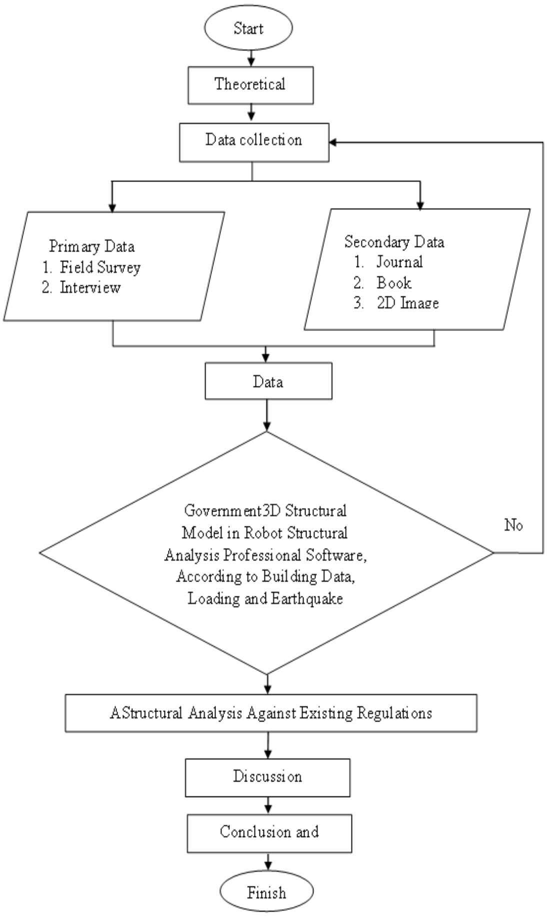
three-dimensional. In addition, its integration with Autodesk Revit allows for efficient coordination in a BIM environment, speeding up the design process and minimizing errors. With support for various international design standards and comprehensive analysis reporting features, RSAP becomes an effective tool for producing safe, efficient, and code-compliant designs for multi-story buildings. Therefore, the use of RSAP in this research aims to obtain accurate and applicable analysis results for multi-story building structures (Dyfiantifa et al, 2025).

Materials and Methods

The location and time of this research are situated at Aminah Hospital in Blitar City. This research is conducted to evaluate the effectiveness of the structure to determine its compressive strength. The research location is on Kenari Street in Blitar City as shown in Figure 1 below:

Figure 1 Location of the Aminah Hospital Construction
(Source: Google Earth)

Research Concept Flowchart



Data Analysis TechniquesThe data analysis technique used in this thesis is quantitative analysis. Data analysis is a technique for analyzing data in numerical form. Quantitative analysis aims to produce findings that can be generalized, which means they can be applied broadly. The analytical technique in this thesis has several stages. The stages that need to be carried out include:

Data Processing Data processing is conducted when all secondary data required is deemed sufficient. This data processing involves the calculation of the building structure for the Islamic Hospital Aminah construction in Blitar City, assisted by Robot Structural Analysis Professional software.

Data AnalysisThe results obtained from data processing are then analyzed. The data analysis used is through the Robot Structural Analysis Professional application using the Analysis Design method. The data processing analysis stage is also assisted by the Robot Structural Analysis Professional application. The following are the steps for data analysis:

1. Structural modeling in RSAP softwareThe creation of a structural model for the Islamic Aminah Hospital building with 3D modeling according to the working drawings (Shop drawing). In the software, it is assumed that the Z-axis is the vertical axis. The global Z-axis is the vertical axis that has an upward direction, and the X-Y axes form a horizontal plane.
   a. Open the RSAP application and then click New. Then select the type of structure you want to use. Then select Frame 3D Design. Click Axis Definition to create a grid first. This is done to make drawing easier. After it's filled, click Apply.
   b. Draw the beams and columns that have been set previously. Geometry > Beam > Select the size of the beam you want to use > Connect the beam by clicking the joint from
   c. the column of the other columns according to the working drawing. Next, draw the beam on the sheet.
   d. Furthermore, the 3D structure modeling image

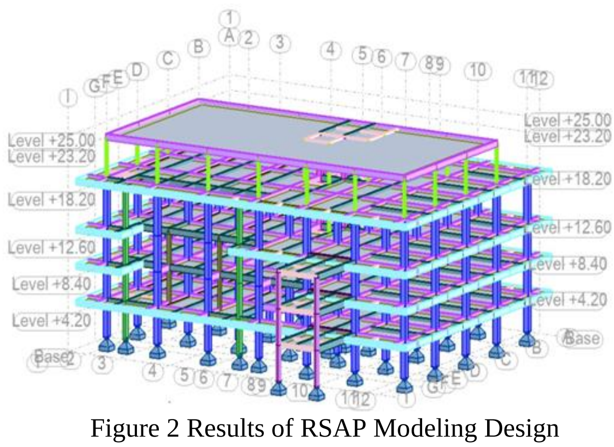


Figure 2 Results of RSAP Modeling Design

2. Load CalculationLoad calculations – the loads acting on the structure include dead load, live load, and earthquake load.

Results

Results of the RSAP 2024 Structure Analysis Based on the three-dimensional structural modeling using the Robot Structural Analysis Professional application, the ultimate moments can be seen in Figure 3 as follows:
The loading calculated based on the existing modeling where loads in the RSAP program are entered as load types.

3. Analysis
   a) The analysis is conducted after the loads are entered into the RASP software by clicking Calculation, resulting in the maximum moment.
   b) Select one member such as a Beam to design reinforcement > Design > Provided Reinforcement of RC element.
   c) To see whether the beam is OK or not, it can be checked through Beam Note.
   d) Repeat the steps as in points b and c for each type of beam or column.

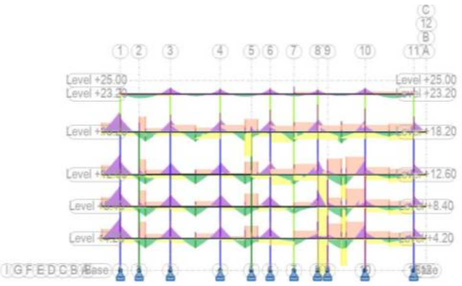


Figure 3 Results of Robot Structural Analysis Professional Analysis
(Source: RSAP Application, 2024)

Structural Analysis Results on Beams

After the author analyzed the results of the structural calculations usingRobot Structural Analysis Professional with concrete quality fc' 30 Mpa and steel reinforcement quality (fy), flexural reinforcement 420 Mpa, shear reinforcement 300 Mpa obtained the results of the ultimate moment and the results of the beam reinforcement shown in Table 1 as follows:

Table 1 Beam Moments and Reinforcement

Information	Moment	Reinforcement
B1 (400 x 700) mm	206.26 kNm	Tul. Longitudinal 12D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B2 (400 x 700) mm	91.18 kNm	Tul. Longitudinal 9D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B3 (300 x 700) mm	77.67 kNm	Tul. Longitudinal 9D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B4 (550 x 850) mm	234.17 kNm	Tul. Longitudinal 15D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B5 (400 x 800) mm	170.06 kNm	Tul. Longitudinal 9D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B6 (400 x 700) mm	3.34 kNm	Tul. Longitudinal 9D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B7 (200 x 700) mm	52.82 kNm	Tul. Longitudinal 6D16 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B8 (250 x 500) mm	0.86 kNm	Tul. Longitudinal 4D16 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B9 (300 x 700) mm	-123.90 kNm	Tul. Longitudinal 6D16 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)
B10 (300 x 700) mm	21.51 kNm	Tul. Longitudinal 8D19 Tul. Transvesal D10 – 150 (Lap.) Tul. Transvesal D10 – 100 (Tump.)

(Source: RSAP Application Output Results)

Based on Table 1 above, the author can explain that the type B1 beam with dimensions (400 x 700) mm has an ultimate moment or MU of 206.26 kNm with the main reinforcement using threaded iron with a diameter of 19 mm with a total of 12 rods and for the stirrup reinforcement using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the support direction.

In the type of Beam 2 size (400 x 700) mm has an ultimate moment/Mu of 91.18 kNm with reinforcement with the main reinforcement using threaded iron with a diameter of 19 mm with a total of 9 rods and for the reinforcement of the stirrups/begel using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the direction of the field, a distance of ten centimeters (10) cm in the direction of the support.

Furthermore, the ultimate moment /Mu of Beam 3 (300 x 700) mm has an ultimate moment /Mu of 77.67 kNm with reinforcement using threaded iron with a diameter of 19 mm with a total of 9 bars and for the reinforcement of stirrups / stirrups using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the support direction.

For Mu or the ultimate moment on Beam 4 (550 x 800) mm is 234.17kNm with reinforcement with main reinforcement using threaded iron with a diameter of 19 mm with a total of 15 bars and for the reinforcement of stirrups/begel using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the direction.

Then Mu or the ultimate moment on Beam 5 (400 x 800) mm is 170.06 kNm with reinforcement with the main reinforcement using threaded iron with a diameter of 19 mm with a total of 9 rods and for the reinforcement of the stirrups/begel using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the direction of the field, a distance of ten centimeters (10) cm in the direction of the support.

In Beam 6 (400 x 700) mm the ultimate moment is 3.34 kNm with reinforcement with main reinforcement using threaded iron with a diameter of 19 mm with a total of 9 bars and for the stirrup reinforcement using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the support direction.

Furthermore, the ultimate moment on Beam 7 (200 x 700) mm is 52.82 kNm with reinforcement using threaded iron with a diameter of 16 mm with a total of 6 bars and for the stirrup reinforcement using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the support direction.

The Mu or ultimate moment on Beam 8 (250 x 500) mm is 0.86 kNm with reinforcement using threaded iron with a diameter of 16 mm with a total of 4 rods and for the reinforcement of the stirrups/stirrups using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the support direction.

For the minimum Mu on Beam 9 (300 x 700) mm is -239.90 kNm with reinforcement with main reinforcement using threaded iron with a diameter of 16 mm with a total of 6 rods and for the reinforcement of stirrups/stirrups using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the direction of the field, a distance of ten centimeters (10) cm in the direction of the support.

Meanwhile, in Beam 10 (300 x 700) mm, the ultimate moment is 21.51 kNm with reinforcement using threaded iron with a diameter of 19 mm with a total of 8 rods and for the reinforcement of stirrups/stirrups using threaded iron with a reinforcement diameter of D10 with a distance of fifteen centimeters (15) cm in the field direction, a distance of ten centimeters (10) cm in the direction of the support. The results of the beam reinforcement using the RSAP application can be seen in Figure 4 as follows:

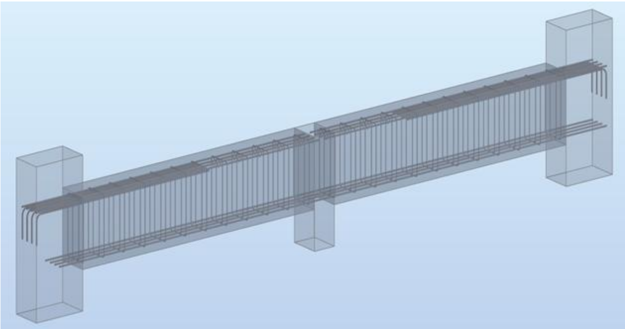


Figure 4 Beam Reinforcement Image Using RSAP 2024 Application
(Source: RSAP Application, 2024)

Results of Structural Analysis on Columns

After analyzing the results of the structural calculations on the beam, the author continued to analyze the column structure usingRobot Structural Analysis Professional with concrete quality fc' 30 Mpa and steel reinforcement quality (fy), flexural reinforcement 420 Mpa, shear reinforcement 300 Mpa and obtained the results of the ultimate moment and column reinforcement results shown in Table 2 as follows:

Table 2 Column Moments and Reinforcement

Information	Moment	Reinforcement
K1 (700 x 700) mm	166.88 kNm	Tul. Longitudinal 20D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 -

		150
K2 (700 x 700) mm	81.79 kNm	Tul. Longitudinal 20D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 – 150
K3 (700 x 700) mm	0.36 kNm	Tul. Longitudinal 20D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 – 150
K4 (700 x 700) mm	6.10 kNm	Tul. Longitudinal 20D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 – 150
K5 (600 x 600) mm	8.92kNm	Tul. Longitudinal 12D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 – 150
K6 (400 x 700) mm	4.27 kNm	Tul. Longitudinal 12D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap) Tul. Hook D10 – 150
K7 (Diameter 600) mm	51.14 kNm	Tul. Longitudinal 10D19 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap)
K8 (400 x 400) mm	7.22 kNm	Tul. Longitudinal 12D16 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap)
KL (250 x 400) mm	11.53 kNm	Tul. Longitudinal 14D10 Tul. Transvesal D10 – 100 (Tump) Tul. Transvesal D10 – 150 (Lap)

(Source: RSAP Application Output Results)

Based on Table 2, the results of the column structure analysis can be seen that the ultimate moment in the Z or Mz direction in Column K1 with dimensions (700 x 700) mm is 166.88 kNm with the main reinforcement using 19 mm diameter threaded iron, 20 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

In Column 2 (700 x 700) mm, the ultimate moment in the Z direction is 81.79 kNm with the main reinforcement using 19 mm diameter threaded iron, 20 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Furthermore, in Column 3 (700 x 700) mm, it has an ultimate moment in the z / Mz direction of 0.36 kNm with the main reinforcement using 19 mm diameter threaded iron, 20 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

For Column 4 (700 x 700) mm, it has a moment of 6.10 kNm with the main reinforcement using 19 mm diameter threaded iron, 20 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Then Mz in Column 5 (600 x 600) mm is 8.92 kNm with the main reinforcement using 19 mm diameter threaded iron, totaling 19 rods with stirrups/stirrups with a diameter of 10 mm, the distance between each stirrup/stirrup is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Mz in Column 6 (400 x 700) mm is 4.27 kNm with the main reinforcement using 19 mm diameter threaded iron, 12 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Mz in Column 7 (Dia 600) mm is 51.14 kNm with the main reinforcement using 19 mm diameter threaded iron, 10 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Mz in Column 8 (400 x 400) mm is 7.22 kNm with the main reinforcement using 16 mm diameter threaded iron, 12 lengths with stirrups/begels with a diameter of 10 mm, the distance between each stirrup/begel is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm.

Mz on Column KL (250 x 400) mm is 11.53 kNm with the main reinforcement using 14 10 mm diameter threaded iron with 10 mm diameter stirrups, the distance between each stirrup is fifteen centimeters (15) in the field and ten centimeters (10) at the support for column reinforcement using 10 mm diameter iron with a spacing of thirty (30) cm. The results of column reinforcement using the RSAP application can be seen in Figure 6 as follows:

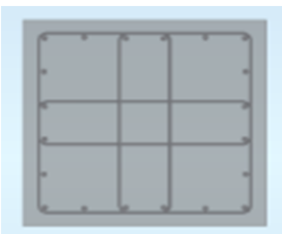


Figure 6 Column Reinforcement Image Using RSAP 2024 Application
(Source: RSAP Application, 2024)

Results of the Evaluation of the Effectiveness of Structural Calculations

Based on the results of structural analysis using RSAP, the reinforcement of beams and columns has met the requirements for structural reinforcement, with the same dimensions of beams and columns using the RSAP application is more effective and efficient than the results of the work plan drawings. Meanwhile, after evaluating the floor slab work from the plan drawings, there is a risk of excessive deflection due to the reinforcement spacing being too wide, so the floor slab work is not effective in strengthening the structure, therefore the reinforcement spacing can be closer.

Discussion

Based on the results of the analysis using Robot Structural Analysis software ProfessionalThere are differences from the previous plan. However, the analysis performed has the same function: to create a sturdy building structure. The differences from the previous plan can be seen in Table 3 below:

Table 3 Evaluation of RSAP Reinforcement Results with Plan Drawings

Description	**RSAP Results**	**Plan Drawing**	**Analysis Results**
Beam B1 (400 x 700) mm			
Main Reinforcement	12 D19	11 D25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	Support D10 - 75 D10 Field - 100	
Beam B2 (400 x 700) mm			
Main Reinforcement	9 D19	9 D25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	Support D10 - 75 Field D10 -100	
Beam B3 (300 x 700) mm			
Main Reinforcement	9 D19	7 D19 4 D10	Based on the author's evaluation

Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	Support D10 - 75 Field D10 -100	with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Beam B4 (550 x 850) mm			
Main Reinforcement	15 D19	15 D25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	Support D10 - 75 Field D10 -100	
Beam B5 (400 x 800) mm			
Main Reinforcement	9 D19	9 D25 4 D 10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	Support D10 - 75 D10 -150 Field	
			is more effective and efficient.
Beam B6 (400 x 700) mm			
Main Reinforcement	9 D19	9 D25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	D10 - 100 Support Field D10 -100	
Beam B7 (200 x 700) mm			
Main Reinforcement	6 D16	4 D 25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	D10 - 100 Support Field D10 -100	
B8 (250 x 500) mm			
Main Reinforcement	4 D16	4 D 19 2 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	D10 - 100 Support D10 -150 Field	

			not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Beam B9 (300 x 700) mm			
Main Reinforcement	6 D16	7 D 25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	D10 - 100 Support Field D10 -100	
Beam B10 (300 x 700) mm			
Main Reinforcement	8 D19	8 D 25 4 D10	Based on the author's evaluation with the same beam dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement	D10 - 100 Support D10 -150 Field	D10 - 100 Support Field D10 -100	
Column K1 (700 x 700) mm			
Main Reinforcement	20 D19	36 D25	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150 Hook D10 - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	
Column K2 (700 x 700) mm			
Main Reinforcement	20 D19	32 D25	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150 Hook D10 - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	
Column K3 (700 x 700) mm			
Main Reinforcement	20 D19	32 D24	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150 Hook D10 - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	

			application which is more effective and efficient.
Column K4 (700 x 700) mm			
Main Reinforcement	20 D19	28 D25	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150 Hook D10 - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	
Column K5 (600 x 600) mm			
Main Reinforcement	12 D19	16 D25	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150 Hook D10 - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	
Column K6 (600 x 600) mm			
Main Reinforcement	12 D19	20 D25	dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150	D10 - 100 Support D10 Field - 150	

	Hook D10 - 150	Hook D10 - 150	not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Column K7 (Dia 600) mm			
Main Reinforcement	10 D19	16 D25	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150	D10 - 100 Support D10 Field - 150 Hook D10 - 150	
Column K8 (400 x 400) mm			
Main Reinforcement	12 D16	16 D19	Based on the author's evaluation with the same column dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.
Stirrup Reinforcement and Hook	D10 - 100 Support D10 Field - 150	D10 - 100 Support D10 Field - 150	
Column Kl (250 x 400) mm			
Main Reinforcement	14 D10	8 D16	Based on the author's evaluation with the same column
Stirrup Reinforcement	D10 - 100	D10 - 100	

and Hook	Support D10 Field - 150	Support D10 Field - 150	dimensions, the planner's reinforcement has met the structural strengthening requirements, however, the reinforcement is not as effective and efficient as reinforcement using the RSAP application which is more effective and efficient.

(Source: Author's Analysis Results)

Based on Table 3 above, there are analysis results that are very clearly visible in the reinforcement. Reinforcement in beams and columns from the analysis results using the RSAP application is more efficient and effective than reinforcement in the design drawings with the same beam and column dimensions in the design drawings. for reinforcement in the analysis results using the RSAP application is more effective but not efficient because the reinforcement spacing is closer and wasteful, so this study is more efficient and effective in accordance with the research of Egrid Ayu Dyfiantifa et al. which states that the use of the RSAP application is more effective and efficient in calculating beam and column structures.

Conclusion

Based on the results of structural calculations using the Robot Structural Analysis Professional application, the author can draw the following conclusions:

1. Analysis of reinforced concrete structure calculations using the Robot Structural Analysis Professional application produces reinforcement of beams B1, B2, B3, B4, B5, B6 and B10 with main reinforcement diameter D19 mm while in beams B7, B8 and B9 the main reinforcement diameter D16 mm. For column work K1, K2, K3, K4, K5, K6 and K7 use main reinforcement with diameter D19 mm, while in column K8 the main reinforcement diameter D16 mm, for KL the diameter D10 mm.
2. The results of the evaluation of the effectiveness of structural calculations using the Robot Structural Analysis Professional applicationThe reinforcement of the beams and columns has met the structural strengthening requirements, with the same beam and column dimensions using the RSAP application is more effective and efficient than the results of the work plan drawings. Meanwhile, after evaluating the effectiveness of the floor slab work, it does not meet the structural requirements due to the risk of excessive deflection due to the reinforcement spacing being too wide.

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