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Structural Analysis of Beams in One of the Health Service Buildings in Pemalang

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Abstract

To achieve a quality building in terms of safety, comfort, and cost efficiency, it is necessary to plan and calculate the building structure in accordance with the Indonesian National Standard (SNI) in order to fulfil the applicable construction requirements. Based on optimal safety and service criteria, the planning process must comply with SNI 1727-2019, and building structure planning must follow SNI 2847-2020 regarding reinforced concrete, as the latest regulation. The structure was analysed using ETABS software, with concrete as the material for beams, columns, and floor slabs, and concrete deck for the roof structure. The results of this process include analysis and structural design drawings for Harapan Sehat hospital Pemalang.

INTRODUCTION

Research in analysing the structure of type D hospital buildings can include several specific points that are relevant to the characteristics and needs. for type D hospital buildings can be explained by looking at the number of human resources (HR) which includes medical, pharmaceutical, nursing, health, and non-health staff. For medical services, there are 4 general practitioners who handle basic medical services, 1 general dentist for dental and oral care, and 1 specialist doctor for each type of basic specialist medical service. In pharmaceutical services, there is 1 pharmacist who serves as the head of the pharmaceutical installation, 1 pharmacist in charge of inpatient care with the support of 2 pharmacy technicians, and 1 pharmacist coordinator for drug receipt, distribution, and production. For nursing services, thereare 2 nurses serving 3 beds, with qualifications and competencies adjusted to hospital standards. Types of Nursing Services, adjusted to the hospital's kebidanan.

Capacity and service needs Type D hospitals often serve smaller populations or in rural areas. Nonetheless, the demand for quality health services remains high. Therefore, it is necessary to conduct structural analyses to ensure that the building is able to bear the service load that matches its capacity.

Resource constraints Type D hospitals may have limitations in terms of resources, including budget for maintenance and upkeep. Structural analysis needs to consider efficient and cost- effective solutions to ensure the safety and security of the building by utilising the available resources.

Geographical and environmental conditions Type D hospitals are often located in areas that may be vulnerable to certain environmental threats, such as earthquakes or flooding. Structural analyses must take these factors into account to ensure the reliability of the building in the face of potential natural disasters.

Flexibility and customisation As there may be changes in healthcare needs or medical technology, type D hospitals should be designed with sufficient flexibility for future customisation. Structural analyses should consider the building's ability to respond to these changes without compromising safety or stability. Importance of accessibility Type D hospitals are often the focal point of health services for the local community. Therefore, the accessibility of this building for patients and medical staff should be considered in the structural analysis to ensure that the building can be easily accessed by all parties in need. Considering the unique characteristics and challenges faced by Type D hospitals, structural analyses are important to ensure that the building meets the standards of safety, reliability and functional feasibility required to provide quality healthcare to the community.

There are various classifications of hospitals in Indonesia. In this study, researchers chose a type D hospital located in Pemalang City, Central Java. Researchers chose Harapan Sehat Hospital which is located on Jl. R.E. Mertadinata, Pelutan, Pemalang District, Pemalang Regency, Central Java. This analysis aims that in designing a building structure it is very necessary to adhere to the science of civil engineering and the criteria for a building structure according to SNI 1727: 2020, SNI 2847: 2019, SNI 1726: 2019 and PPURG 1987 so that a sturdy and safe building will be created.

METHOD

The research methodology in this researcher uses 2 methods, namely, quantitative and qualitative methods. In its application, the quantitative method begins with collecting field data which is used as the basis of information for the object, and the modelling design is carried out using supporting software, namely ETABS on the building structure to be analysed, namely the hospital building structure located on Jl. R.E. Mertadinata, Pelutan, Pemalang District, Pemalang Regency, Central Java.

The data applied in this research is looking for existing such as land area, building area, Harapan Sehat Hospital plan drawings and structural dimensions. Then for the application of qualitative methods in this paper is to look for previous literature studies such as theses, journals, civil engineering books or other media such as (internet) and interviews with experts and experienced people regarding the analysis of building structures including interviews with certain civil engineering lecturers at Swadaya Gunung Jati University Cirebon. After that, process and analyse the data obtained. As well as planning the Harapan Sehat Pemalang Hospital Building according to the 2019 loading SNI. Then draw conclusions and recommendations based on the results of the analysis.

The data processing methods and methods to be used will be discussed in detail in a separate chapter. This is important because this stage is very crucial and decisive in the design planning of a building. The discussion will be carried out in detail and specifically, so it requires a specialchapter to support the conclusion drawing process.

The stages of data analysis applied in this writing are loading calculations and building structure calculations. The loading calculation consists of earthquake loads, dead loads, live loads, wall loadsand rain loads. Then in the calculation of the building structure only on the beam dimensions

This research methodology consists of several stages, as follows:

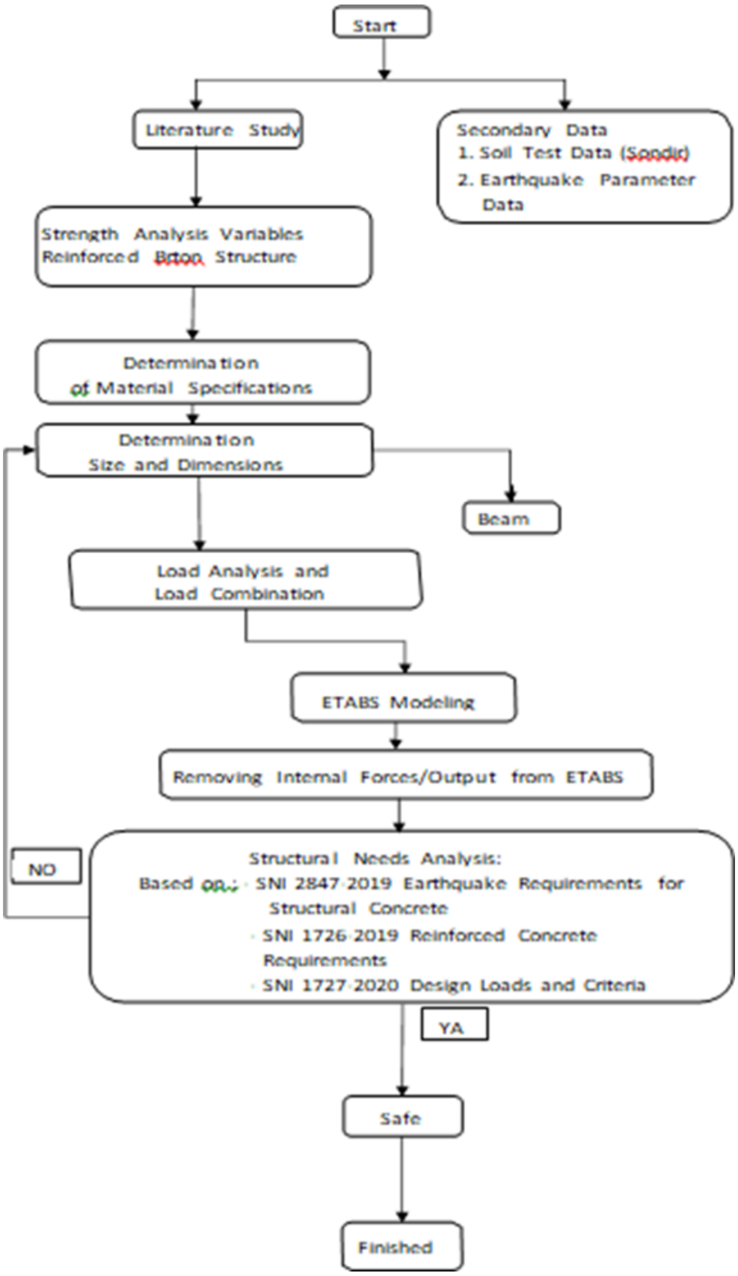


Figure 1. Research Flow Framework

RESULTS AND DISCUSSION

The loading calculation data for Harapan Sehat Hospital is attached below:

Live Load

1	Laboratory Operating Room	=	2,87	kN/m^2	*reduction*
2	Patient Room	=	1,92	kN/m^2	*reduction*
3	Corridor	=	3,83	kN/m^2	*reduction*
4	1st Floor Corridor	=	4,79	kN/m^2	*reduction*
5	Roof Load	=	0,96	kN/m^2	*reduction*

Dead Load

DEAD LOAD OF FLOOR PLATE 1						
Load Component	**Thickness (m)**		**Weight (kg)**		**Result**	
Ceramic	0,01	m	24		0,24	kN/m2
Spesi	0,03	m	21		0,63	kN/m2
Waterproofing	0,01	m	0		0	kN/m2
MEP	1				0	kN/m2
Celling and Frame	1				0	kN/m2
				Total	0,87	kN/m2
DEAD LOAD OF FLOOR PLATE 2						
Load Component	**Thickness (m)**		**Weight (kg)**		**Result**	
Ceramic	0,01		24		0,24	kN/m2
Spesi	0,03	m	21		0,63	kN/m2
Waterproofing	0,05	m	0		0	kN/m2
MEP	1		25	0,25	0,25	kN/m2
Celling and Frame	1		18	0,18	0,18	kN/m2
				Total	1,292	kN/m2
DEAD LOAD OF ROOF PLATE						
Load Component	**Thickness (m)**		**Weight (kg)**		**Result**	
Waterproofing	0,01	m	14		0,14	kN/m2
Spesi	0,03	m	21		0,63	kN/m2
Celling and Frame	1	m	18	0,18	0,18	kN/m2
MEP	1		25		0,25	kN/m2
				Total	1,192	kN/m2

Rain Load

This load is obtained referring to SNI 1727: 2020 Article 8.3.

a. Rain load = 0.0098 (ds+dh)
   ds and dh are assumed to be 50mm.
   R = 0,0098
   ds = 50 mm dh = 50 mm
b. Rain Load = R x (ds + dh)
   = 0,0098 x (50 + 50)

= 0.0098 x (100) = 0.98 kN/m²

Wall Load

The wall load refers to SNI 1727:2020, Table C3.1-2. The wall used is a hebel brick type wall, where the weight of hebel brick is half the weight of red brick. The weight of red brick itself according to SNI 1727:2020 is 1.87 kN/m². Then the weight of hebel bricks is 1.87:2 = 0.935 kN/m². Then multiply the height of each floor.

WALL LOAD				
Dead Load Type	**Weight (kN/m2)**	**Scale**	**Q (kN/m2)**	**Q (kN/m2)**
Hebel Brick T = 10 cm	0,935	1	0,935	0,94
1 cm Plastering Mortar	0,24	2	0,48	0,48
		QD=		1,42
			QD usd =	1,5

1st floor with an inter-storey height of 5 metres Lt.1 = 5 x 1.5 = 7.5 kN/m²

2nd floor with an inter-storey height of 4 metres Lt.2 = 4 x 1.5 = 6 kN/m²

Earthquake Load

a. Risk category = IV
b. Site class = SD (medium soil)
c. (Ss) = 0.5968 g
d. (S1) = 0.2985 g
e. Fa = 1.4
f. Fv = 2.0
g. SMS = 0.836 g
h. SM1 = 0.597 g
i. SDS = 0.557 g
j. SD1 = 0.398 g
k. KDS = D
l. (Ie) = 1.50
m. (R) = 8
n. (Ω()) = 3
o. (Cd) = 5.5

From the above data, the results of the earthquake spectrum are shown in Figure 3.

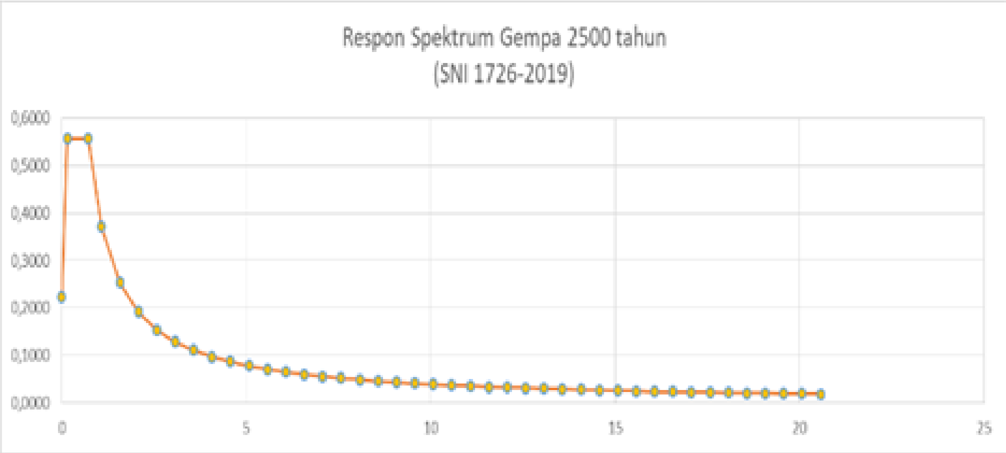


Figure 2. Response Spectrum of Pemalang City Area

To carry out the planning, structural modelling was carried out using ETABS v.18 structural analysis software. The material entered for the beam structure in the ETABS programme is concrete with a quality of fc 25 MPa. This structural model isgiven a load that is in accordance with the SNI reference.

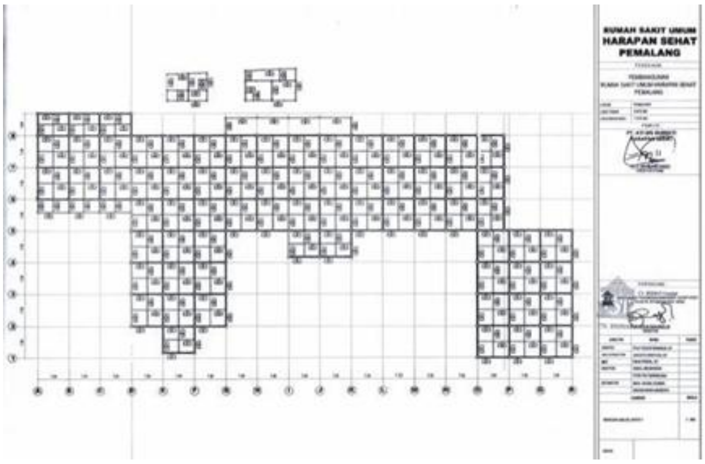


Figure 3. Beam plan of RSHS Pemalang

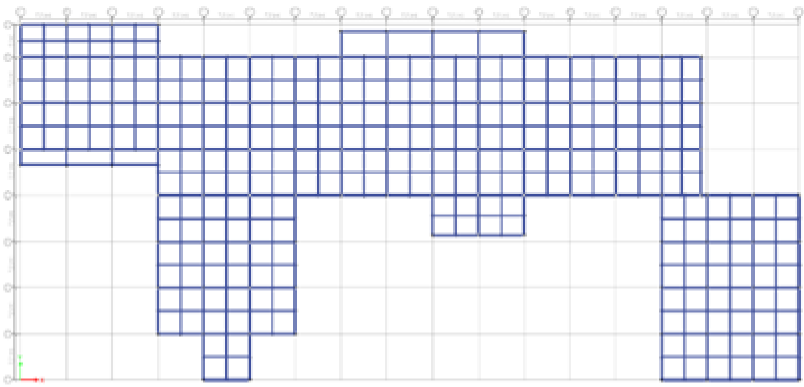


Figure 4. Beam Modelling In ETABS (Top View)

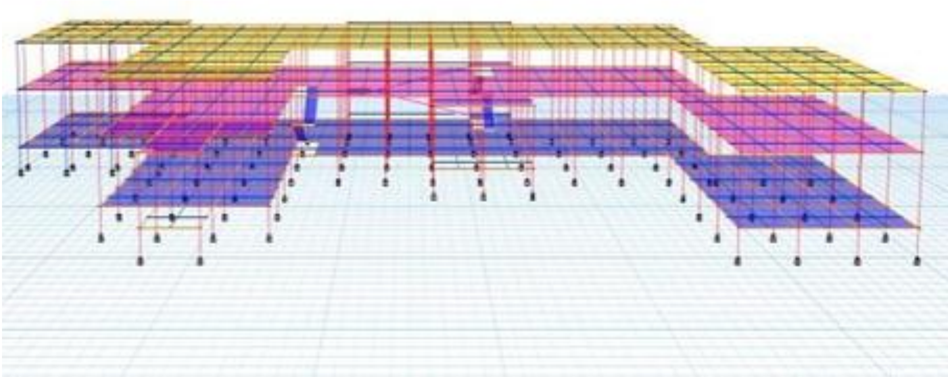
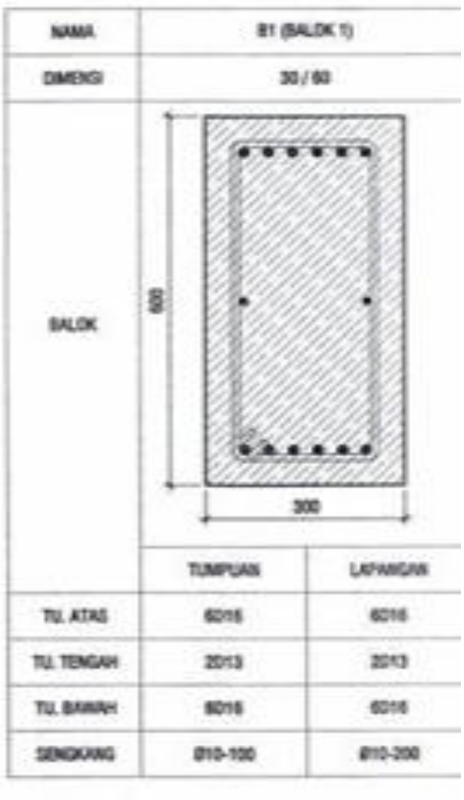


Figure 5. Structure Modelling (Front View)

From the results of the beam structure analysis, the construction of the Harapan Sehat Pemalang Hospital building is very important to support the service activities of patients or hospital visitors. The planning of hospital buildings that use concrete structures, and apply SNI 2019 in the loading reference, it is found that the use of structural profiles in the construction of hospital buildings is.



NAMA	B1 (BALOK 1)	
DIMENSI	30 / 60	
BALOK	600 / 300	
	TUMPUAN	LAPANGAN
TU. ATAS	6D16	6D16
TU. TENGAH	2D13	2D13
TU. BAWAH	6D16	6D16
SENGKANG	Ø10-100	Ø10-200

Figure 6. Structural profile of type B1 beam of hospital building

In the beam structure profile above, after entering all the loading and then analysing the output results / internal force results from ETABS based on the largest load from the moment force and shear force, there is 1 type of beam that is considered less effective to be applied to the Harapan Sehat Pemalang Hospital building structure, namely Beam 1 (B1) with the output value / internal force value:

Positive plan moment resulting from the factored load (Mu+) = 164.193 kN/m,

Negative plan moment resulting from the factored load (Mu-) = 220.503 kN/m ,

Plan Shear Force

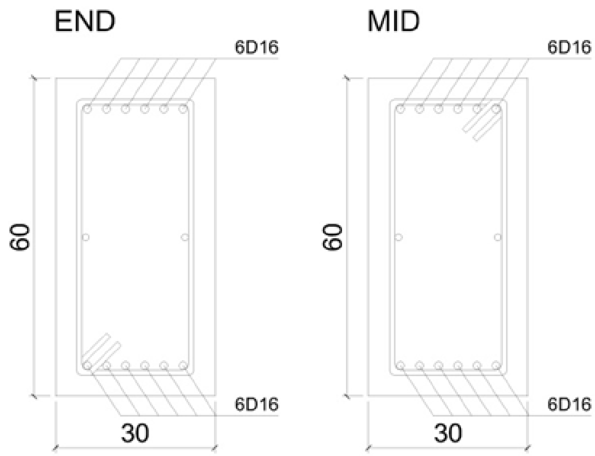


Figure 7. Illustration of Initial Beam Reinforcement

The output result of positive bending moment is 164.193 kN/m, reinforcement must be installed at the bottom of the beam to handle this bending moment. The number and diameter of the bottom reinforcement bars were calculated based on this bending moment according to the relevant design codes such as, reinforcement ratio used, number of reinforcements required, reinforcement area used, moment resistance capacity of the beam, as well as strain check.

The output negative bending moment of 220.503 kN/m indicates that reinforcement needs to be installed at the top of the beam to handle this bending moment. Since the negative moment is greater than the positive moment, the reinforcement in this area should be stronger or denser and calculated based on this bending moment according to the relevant design codes such as, the ratio of reinforcement used, the amount of reinforcement required, the area of reinforcement used, the moment resistance capacity of the beam, as well as the strain check.

Shear force output results with an output of Vu = 178.805 kN/m, shear force (Vu) is the internal force that arises in a beam or plate due to the applied load. This force causes shear along the cross section of the beam. In this case, it is necessary to calculate the required shear reinforcement area and determine the appropriate spacing between stirrups.

With reference to SNI 2847:2019 Article 11.5-Design Strength regarding structural concrete requirements for buildings and explanations, for each combination of factored loads, the design strength must fulfil $\phi Sn \geq U$, including a) to c). The interaction between axial and moment loads must be considered.

a. $\phi Pn \geq Pu$
b. $\phi Mn \geq Mu$
c. $\phi Vn \geq Vu$

In the structural analysis of this beam, the design strength of the beam fulfils all the designstrength requirements. However, the amount of reinforcement in Beam 1 (B1) can be considered too much. This can be considered ineffective because beam 1 (B1) uses 6 pieces of 16 mm diameter reinforcement in each placement of the pedestal and field reinforcement, which in its application the amount of reinforcement will be quite close together as illustrated in the picture above which may result in high costs because the more reinforcement used, the higher the material and labour costs required to install it. This can significantly increase the total cost of the construction project. Then at the implementation stage, there are difficulties in casting because the excessive amount of reinforcement can make the casting process difficult and the concrete aggregate cannot enter the gaps of the reinforcement located at the ends, requiring more work in terms of preparation and execution. On the other hand, too much reinforcement can lead to over-reinforcing, where the structure becomes too stiff and inflexible. This can reduce the ability of the structure to absorb earthquake energy or other dynamic loads and even increase the self-weight of the structure because the more reinforcement used, the heavier the concrete structure becomes. This can be especially problematic in the planning of tall structures or structures that require complex transport and installation, as well as earthquake resistance. Hospitals are often considered critical buildings that must continue to function even after an earthquake. The use of larger diameter steel can increase earthquake resistance and provide better protection against structural damage.

Because considering the original data of Beam 1 (B1) needs to be evaluated, the structure of Beam 1 (B1) needs to undergo changes by increasing the dimensions of its main reinforcement. The original diameter of the main reinforcement is 16mm, increased to 19mm, as attached in the table below :

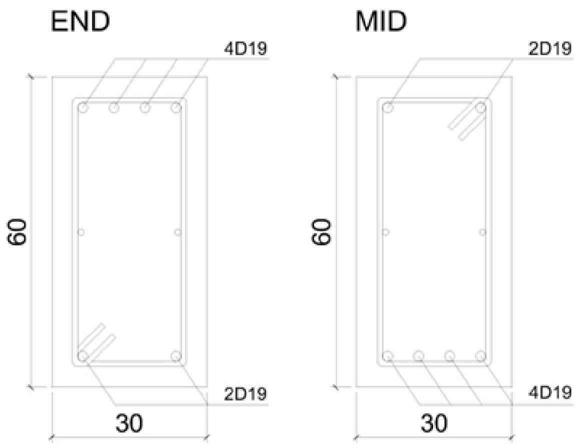


Figure 8. Illustration of Beam Reinforcement After Evaluation

CONCLUSION

The change of reinforcement dimension in the hospital's B1 beam, from the initial diameter of 16 mm to 19 mm, following the standards of SNI 2847:2019 (Procedure for Planning Steel Structures for Building), SNI 1727:2020 (Minimum Loads for Planning Buildings and Other Structures), and SNI 1726:2019 (Procedure for Planning Earthquake Resistance for Building and Non-Building Structures), as well as the 1987 Government Regulation (PPURG) on Building, has significant implications in terms of safety, reliability, and compliance with applicable building regulations in Indonesia. Based on these standards, several summaries can be drawn as follows: At the structural loading analysis stage, this process is important to understand the loads to be received by the beams, so as to ensure the safety and performance of the structure. For structural design which includes determining the appropriate dimensions and reinforcement for beams, columns and other elements, which greatly affects the strength and stability of the building. The guidelines used in this research are SNI 1727: 2020, SNI 2847: 2019, and SNI 1726: 2019 to ensure that the structural analysis meets the established safety and quality standards, and redesign the structure if the analysis results show that the design does not meet the requirements, then revisions need to be made to ensure that the structure is safe, efficient, and in accordance with regulations.

To improve the results obtained, there are things that are worth paying attention to such as, structural planning evaluation before making changes to reinforcement dimensions, it is important to conduct a thorough structural planning evaluation. This includes revising or adjusting the structural design in accordance with the latest standards, such as SNI 2847:2019 on Planning Procedures for Steel Structures for Building. Ensure the selection of reinforcement materials that comply with applicable standards and specifications. In accordance with SNI 1727:2020 by closely monitoring the procurement and installation of reinforcement. Ensure that the materials used meet the strength and safety requirements, and that the installation process is carried out properly in accordance with the technical instructions of SNI 2847:2019. It is also important to consider earthquake resistance in the context of earthquake resistance, in accordance with SNI 1726:2019, to re-evaluate the structural capacity to earthquake forces. Changes in reinforcement dimensions can affect the structural response to vibration and deformation during an earthquake. Therefore, it is recommended to carefully analyse the earthquake resistance and, if necessary, make design adjustments to ensure that the structure can safely bear the earthquake load and conduct tests along with regular monitoring of the structure after the changes are made. This is important to ensure that changes in reinforcement dimensions deliver the expected results in improving structural capacity and reliability. In addition, continuous monitoring can help identify potential problems or changes in structural behaviour that require further corrective action.

By applying the above issues systematically and carefully, it is expected that the change of reinforcement dimension from 16 mm to 19 mm in the beam structure can be implemented efficiently and safely. This will support the improvement of structural performance, safety, and resistance to various environmental conditions that may occur in the hospital.

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