

Planning Analysis of the Upper Structure of the Disaster Logistics Warehouse of BPBD Bantul Regency with SAP2000

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Article Information	ABSTRACT
Article History Received : March 21, 2025 Revised : April 08, 2025 Published : April 18, 2025	Indonesia is a country that is very vulnerable to natural disasters, especially earthquakes, because of its position in the Pacific Ring of Fire region. Bantul Regency, Yogyakarta, is one of the earthquake-prone areas that requires disaster-resistant infrastructure, including disaster logistics warehouses as emergency logistics storage and distribution centers. This study aims to analyze the upper structure of the disaster logistics warehouse of BPBD Bantul Regency to be more optimal and earthquake-resistant using SAP2000 software. The secondary data used is technical data ranging from soil type, earthquake zone, dead load, live load, and earthquake load, which are analyzed according to SNI 1726:2019 and SNI 1729:2020 standards. The results showed that the steel profiles used were IWF 350x175x11x7 for the rafter, IWF 200x150x9x6 for front and rear regels, IWF 250x125x9x6 for side regels, and HB 300x300x18x10 for columns. It was found that the regel was unstable due to the failure to withstand lateral loads, but overall, the upper structure of the warehouse worked optimally according to the results of the check design and steel stress check.
Keywords: <i>Warehouse design; Structural safety; Natural disasters; Logistics.</i>	

INTRODUCTION

Indonesia, as an archipelagic country located at the confluence of tectonic plates and located in the Ring of Fire area, is very vulnerable to various natural disasters, such as earthquakes, tsunamis, volcanic eruptions, floods, landslides, and extreme weather (Haris et al., 2023). This diversity of disaster threats demands a comprehensive and adaptive disaster management system (Faizah & Amaliah, 2021). Data from the Regional Disaster Management Agency (BPBD) of Bantul Regency The total number of disaster incidents in 2022 in Bantul Regency, as many as 548 incidents, increased when compared to 2021, namely 373 incidents, which had a significant impact on loss of life, damage to infrastructure, and socio-economic disruption (Lukluk, 2023) . In the context of disaster management, logistics plays a crucial role. Disaster logistics includes a series of integrated activities, ranging from needs planning, procurement, storage, and transportation to the distribution of aid to affected communities. The effectiveness and efficiency of disaster management is highly dependent on a reliable and responsive logistics system. Disaster logistics warehouses serve as aid consolidation and distribution centers, ensuring adequate supply availability and timely distribution (Naryanto et al., 2019) . Therefore, the design and planning of the structure of a disaster logistics warehouse must meet safety standards and resilience to various disaster threats, especially earthquakes (Yan et al., 2021).

Bantul Regency, which is in the Special Region Province of Yogyakarta, has a high level of vulnerability to earthquakes due to its location adjacent to the subduction zone of the Indo-Australian and Eurasian plates, as well as the existence of the Opak active fault. The massive

earthquake in 2006, which devastated parts of Yogyakarta, is a stark reminder of the importance of disaster risk mitigation in the region (Somantri & Maharrani, 2022). One of the crucial elements in disaster management efforts is the existence of a reliable and earthquake-resistant disaster logistics warehouse, considering its role as a storage and distribution center for emergency relief (Adiansyah & Matrani, 2021). However, many logistics warehouses in Bantul Regency have not met earthquake resistance standards, so they have the potential to suffer damage and hinder the aid distribution process when a disaster occurs (Febrioko et al., 2022). To improve the resilience of building structures, analysis using software such as SAP2000 is a strategic step (Hukama & Erizal, 2023). This software allows a comprehensive evaluation of the strength and stability of building structures through the application of a combination of loads according to applicable standards, such as SNI 1726:2019. Through this analysis, structural weaknesses can be identified, as well as appropriate design improvement solutions can be recommended so that the logistics warehouse is able to function optimally in the face of emergency conditions.

Research on the planning of earthquake-resistant structures has been carried out a lot, but research that specifically discusses the analysis of disaster logistics warehouse structures in Bantul while considering local characteristics is still limited. Previous research focused more on residential buildings or office buildings. There is a need for more research on how to use structural analysis with SAP2000 for disaster logistics warehouses in Bantul, considering things like the type of soil, the range of earthquake responses, and the potential for liquefaction (Rini & Idham, 2021). Several previous studies have discussed the logistics aspect of disasters but have not deeply touched on analyzing the structure of warehouse buildings. For example, the study analyzed (Apriawan et al., 2016) the factors that affect the handling of disaster logistics in Central Sulawesi, which include human resources, uncertainty, collaboration, and cooperation. Another research project discusses (Syakina & Nurdianti, 2021) the analysis of logistics management in disaster emergency handling, with a case study in Sumbawa Regency. These studies make an important contribution to disaster logistics management but lack focus on the resilience aspect of warehouse structures.

The durability of the logistics warehouse structure is essential to ensure the functionality and stability of the building in the long term (Pinanggih & Yogaswara, 2023). A logistics warehouse must be designed with various structural factors in mind, such as dead loads, live loads, and dynamic loads due to external factors, especially earthquakes. If the warehouse structure is unable to withstand earthquake loads or unstable in extreme conditions, this can cause damage to the building and disrupt its operations (Ramdhani et al., 2020). Therefore, in-depth structural analysis using software such as SAP2000 is indispensable for evaluating the strength and stability of building structures. Through this software, simulations and calculations can be carried out on the stiffness, ductility, and stability of buildings under various load conditions. With a thorough understanding of the behavior of the structure, more optimal designs can be applied to improve the durability of the building, thus ensuring that the logistics warehouse can function effectively in the long run (Keledar et al., 2021).

This study aims to analyze the upper structure of disaster logistics warehouses in BPBD Bantul Regency using SAP2000 software. The analysis was done in several main steps. The first step was to model the upper structure of the warehouse using local factors, like the Bantul region's geological conditions and earthquake response spectrum (Wardhani et al., 2019). More than that, the loading combination is done according to the standards given in the insert source to make sure that the structural planning is correct and fits the real conditions. Based on the results of the SAP2000 analysis, this study also looks at how well the structure works against different types of loads, such as dead loads, live loads, and loads caused by earthquakes. It looks at the structure's strength, rigidity, stability, and ductility. With this approach, it is hoped that recommendations for the design of optimal logistics warehouse structures that are resistant to disasters, especially earthquakes, can be obtained (SNI 1726:2019).

RESEARCH METHODS

The Bantul Regency BPBD used a secondary data collection method to plan the structure of its disaster logistics warehouse. Secondary data was collected from various literature sources, and technical data was obtained from the Independent Learning Independent Campus (MBKM) activities at the Regional Disaster Management Agency (BPBD) of Bantul Regency.

Secondary data used in planning the structure of the Bantul Regency BPBD logistics warehouse includes technical information that is the basis for designing disaster logistics buildings. The data includes building types, geographical locations, soil types, and earthquake zones, obtained from seismic maps of the local area. In addition, data related to dead loads, live loads, and earthquake loads are also analyzed to ensure that the design of the structure meets safety and disaster resilience standards, in accordance with regulations such as SNI 1726:2019 and SNI 1729:2020. This information is used to support the entire planning stage, from modeling to structural analysis using software such as SAP2000.

A planning flow chart shows the steps that were taken to plan this upper structure. These steps include gathering data, modeling the structure, applying loads, analyzing the results, and deciding about the design. Figure 1 displays the planning flow chart.

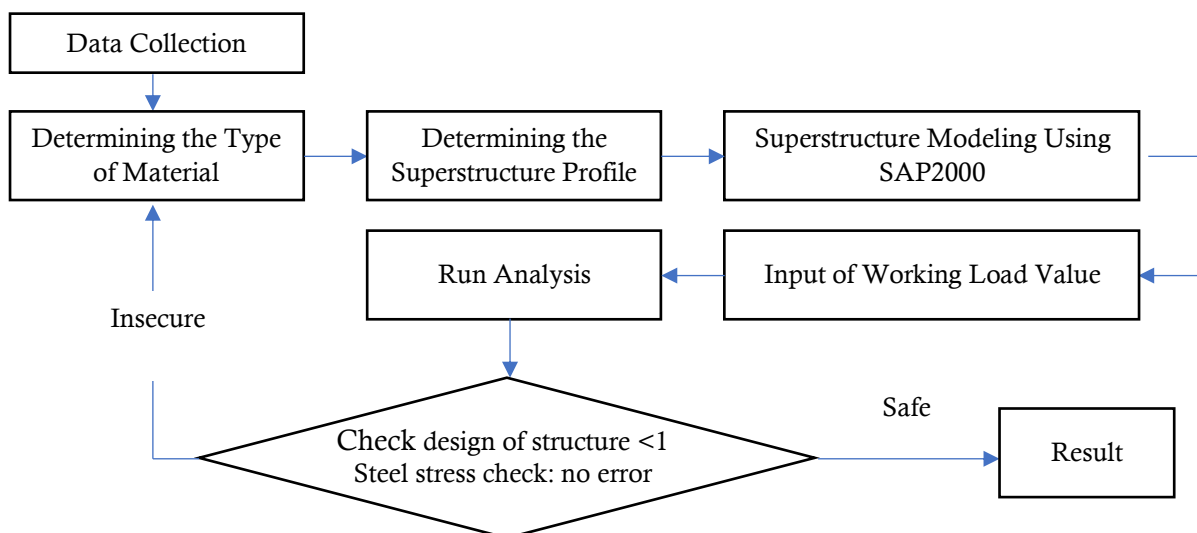


Figure 1. Planning Flow

Building Technical Data

Technical information about the building used in planning the upper structure of the logistics warehouse comes from a collection of detailed documents that describe the warehouse's technical specs and physical traits. Table 1 displays data related to the structural planning of the disaster logistics warehouse in the Bantul Regency BPBD.

Table 1. General Building Data

General Building Data	
Building functions	Warehouse
Location of the building	Bantul
Building height	12.5 m
The height of each floor	6 m
Roof slope	15°
Building length	66 m
Building width	36 m
Soil type	Keep
Earthquake zone	Zone 3 Region

Source: MBKM Internship

The quality of materials used in the planning of the superstructure refers to the characteristics of the material that meet the level of conformity with a certain standard. Material selection is carried out by considering the close relationship between material quality and material properties, which is the basis for meeting the specific needs of structural applications. Table 2 presents the mechanical properties of structural steel, concrete reinforcement steel, and concrete, which serve as references.

Table 2. The mechanical properties of structural steel

Steel Type	Minimum Breaking Voltage, F_u , (MPa)	Minimum Melting Stress, F_y , (MPa)	Minimum Strain (%)
BJ34	340	210	22
BJ37	370	240	20
BJ41	410	250	18
BJ50	500	290	16
BJ55	550	410	13
Modulus of elasticity	(E) = 200,000 MPa		
Modulus shift	(G) = 80,000 MPa		
Poisson ratio	$(\mu) = 0,3$		
Coefficient of expansion	$(\alpha) = 2 \times 10^{-6}/^{\circ}\text{C}$		

Source: SNI 03 1729:2002

RESULTS AND DISCUSSION

Planning a warehouse structure involves analyzing the various main types of loads, namely dead load, live load on the roof, wind load, and earthquake load. Dead loads consist of the self-weight of the structural elements and other permanent components such as roof coverings and fixed connections. Live load includes temporary loads that may occur during the operational period, such as worker activities or maintenance equipment, and the amount is determined in reference to the SNI 1727:2020 standard, which regulates the minimum value based on the function and accessibility of the roof area.

Wind loads are analyzed based on the lateral pressure acting on the building surface, taking into account the planned wind speed, building shape, and surrounding topographical conditions. Referring to the provisions in SNI 1727:2020, warehouse buildings that generally have wide spans and low heights tend to be more sensitive to wind loads, so it is important to thoroughly analyze the main wind force resisting system. Meanwhile, the earthquake load is calculated based on a dynamic approach in accordance with SNI 1726:2019, taking into account the risk classification, soil type, and seismic location, in order to determine the relevant design response spectrum for the steel structure.

The design process starts from the structural modeling stage, which includes determining the dimensions of structural elements, selecting steel material as the main component, and designing the connection system between elements. Modeling is done by considering structural efficiency and resistance to the most critical load combinations. Steel structure planning refers to the provisions in SNI 1729:2020, which regulates the limit state method to ensure the capacity of elements to flexure, axial, and shear. This approach aims to produce a warehouse structure that meets the criteria of strength, stability, and reliability according to applicable national standards.

Modeling Stages

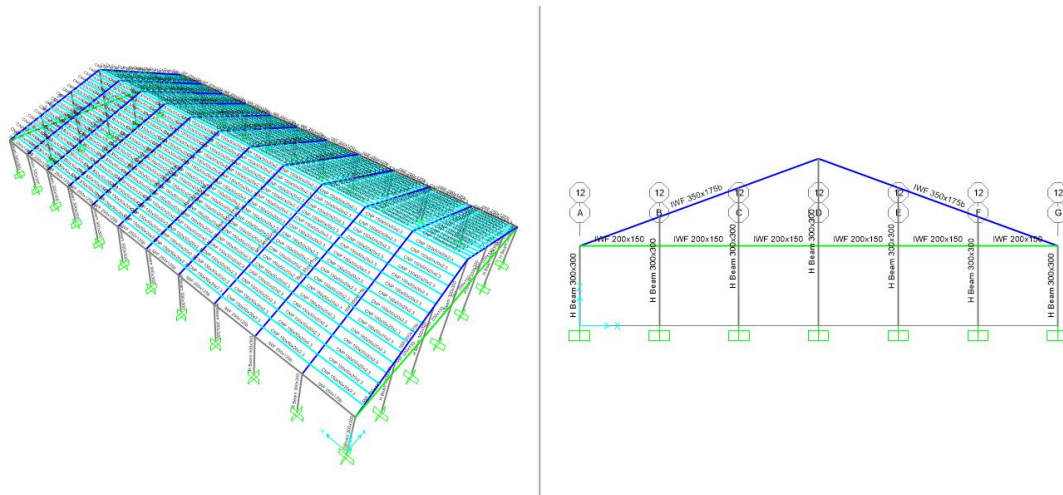
Structural modeling is a crucial step in building planning to ensure stability, safety, and material efficiency. Using SAP2000 software, this stage analyzes and designs key elements like columns, beams, and joints to support load and force simulations. Once the modeling stage is complete, the results of the analysis will provide a specific picture of the material requirements, including the selection of a suitable steel profile. Table 3 displays the table of steel profiles and the dimensions of the used structure 3.

Table 3. Steel Profile and Structure Size

Frame	Size
Rafter	IWF 350x175x11x7
Front and rear regel	IWF 200x150x9x6
Side regel	IWF 250x125x9x6
Column	HB 300x300x18x10

Source: MBKM Internship

The stages in structural analysis generally begin with determining the grid system according to the planned structure. The next step is to determine the type of material to be used in the structure, as well as determine the cross-section of beams, columns, slabs, and other cross-sections. After that, the type of load and the combination of loads that will act on the structure are determined. Furthermore, a drawing of the building frame structure is made in 3D form, and the placement of the pedestal or joints is determined. The load value is then added to the structure, followed by the structural design tension control in accordance with the SNI 2020 reference. Structural analysis is carried out (run analysis) to evaluate the performance of the structure. The results of the analysis are then examined to ensure that the structure is safe. If necessary, revisions are made to ensure the structure meets the desired safety and design criteria. Figure 2 displays the modeling of a disaster logistics warehouse's top structure.

**Figure 2.** Structural modeling with SAP2000

Dead Load And Live Load

SAP2000 automatically calculates dead loads, which encompass the weight of structural elements like columns, beams, and slabs. Additional loads such as rainwater puddles, roof covering materials, and living loads are also considered to ensure roof stability. Table 4 contains the data used for the analysis of dead load and live load. The data used for the analysis of dead load and live load can be found in table 4.

Table 4. Dead and Live Load Data

Dead and Live Load Data	
Rafter distance	6 m
Purlin spacing	1,197 m
Load area	7.18m ²
BMT zinalum load 0.45	0.047 kN/m ²

Source: MBKM Internship

Based on the dead load and live load data, the results of the analysis are as follows:

1. Rainwater load, (assuming 20 mm inundation).

$$R = 0,0098 \times 20 = 0,196 \text{ kN/m}^2$$

2. Roof Load,
 $SDL = (0,047 \times 7,18)/6 = 0,06 \text{ kN/m}^2$
3. The burden of people,
 $Lr = 100 \text{ kg} \approx 0,98 \text{ kN}$
4. Rain Load,
 $R = (0,196 \times 7,18)/6 = 0,23 \text{ kN/m}^2$

Figures 3, 4, and 5 show the results of the load input on the SAP200.

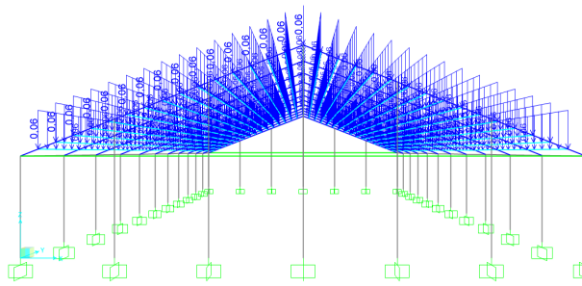


Figure 3. Roof Load Input, SDL

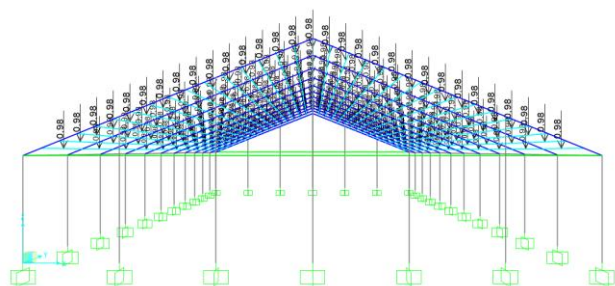


Figure 4. Person Load Input, Lr

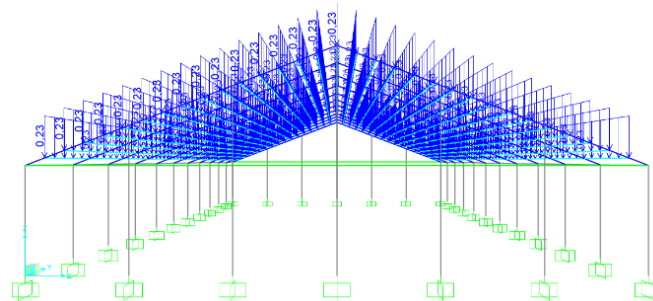


Figure 5. Rain Load Input, R

Wind Load

This study calculates wind load using the reference SNI 1727:2020 and adjusts it to the technical data of related buildings. This process involves analyzing the basic wind speed, location characteristics, and wall pressure coefficient (C_p) to determine the distribution of wind force on the structure. Table 5 displays the wind load data from this study.

Table 5. Wind Load Data

Wind Load Data	
Risk categories	I
Base wind speed, V	38.3 m/s
Angina direction factor, Kd	0,85
Exposure categories	B
Categories topography, Kzt	1
Surface elevation factor, to	1
Wind blowing factor, G	0,85
Koefisien Velocity Pressure Exposure, Kz or Kh	0,70
Length of the building perpendicular to the wind coming, B	66 m
Length of the building in the direction of the incoming wind, L	36 m
L/B	0,545

Source: SNI 1727:2020

The calculation of speed pressure, q_z , was conducted based on the wind data mentioned above.

$$0,613 \times K_z \times K_{zt} \times K_d \times K_e \times V^2 \dots\dots\dots (1)$$

$$q_z = 0,613 \times 0,70 \times 1 \times 0,85 \times 1 \times 38,3^2 = 54,558 \text{ kg/m}^2$$

Wind load analysis uses the wall coefficient (C_p) parameter to measure the pressure or suction of wind on a building's surface. C_p values vary depending on the geometry of the building, wind direction, and the location of the surface being analyzed (e.g., front, side, back, or roof walls). In the planning of logistics warehouse structures, the C_p value is usually obtained from applicable standards or guidelines, such as SNI 03-1727-2020 or international standards such as ASCE 7. Table 6 displays the wall pressure coefficients (C_p).

Table 6. Wall Pressure Coefficient, C_p

Surface	L/B	C_p	Used with
Wind side wall coming	All values	0,8	q_z
	0-1	-0,5	q_h
Wind side wall goes	2	-0,3	q_h
	>4	-0,2	q_h
Edge walls	All values	-0,7	q_h

Source: SNI 1727:2020

Wind pressure, P , is the compressive force produced by the movement of the wind acting on a surface, usually calculated based on the pressure of velocity and the coefficient of pressure.

1. P wall wind coming

$$= q_z \times G \times C_p \dots\dots\dots (2)$$

$$= 54,558 \times 0,85 \times 0,8$$

$$= 37,099 \text{ kg/m}^2$$

2. P the wind wall goes

$$= q_h \times G \times C_p \dots\dots\dots (3)$$

$$= 54,558 \times 0,85 \times (-0,5)$$

$$= -23,187 \text{ kg/m}^2$$

3. P Edge wall

$$= q_h \times G \times C_p \dots\dots\dots (4)$$

$$= 54,558 \times 0,85 \times (-0,7)$$

$$= -32,462 \text{ kg/m}^2$$

Based on article 28.3.4 SNI 1727:2020, the minimum wind pressure is 78.518 kg/m^2 . Since the wind pressure falls below the specified minimum, we use 78.518 kg/m^2 .

$$\text{Listening to Anne, } P = V^2/16 \dots\dots\dots (5)$$

$$\text{Wind speed, } V = \sqrt{P \times 16} \dots\dots\dots (6)$$

$$V = \sqrt{78,518 \times 16} = 35,44 \text{ m/dtk} \approx 79,29 \text{ mph}$$

Earthquake Load

The SS, S1, SDS, and SD1 scores were obtained from the Indonesian Spektra Design Web. This study focused on the Bantul area. The data obtained from the Spektra Indonesia Web Design and SNI 1726:2019 can be seen in Table 7.

Table 7. Earthquake Load Data

Earthquake Load Data	
Ss	1,3827
S1	0,5841
Long period transition period, TL	20
Site classes	D
Site Coefficient, Fa	1
Site Coefficient, Fv	1,5

Source: Web Design Spektra Indonesia and SAP2000

The calculation value of the spectral response curve is obtained as follows:

$$1. Sds = \left(\frac{2}{3}\right) \times Fa \times Ss \dots\dots\dots(7)$$

$$= \left(\frac{2}{3}\right) \times 1 \times 1,3827 = 0,9218$$

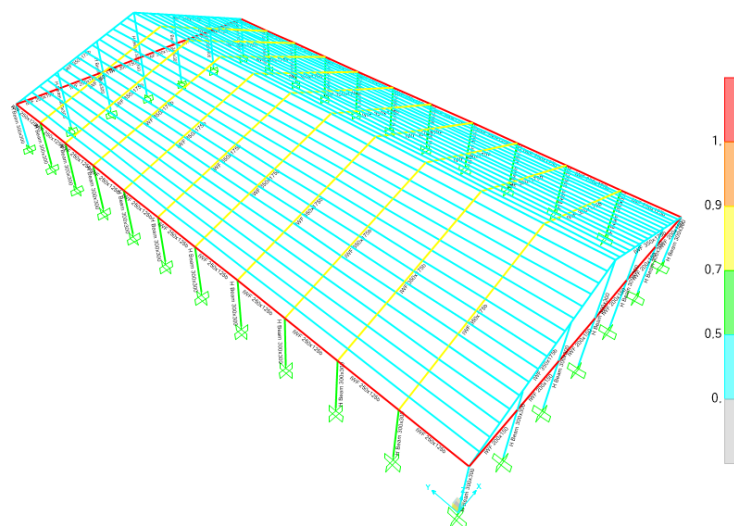
$$2. Sd1 = \left(\frac{2}{3}\right) \times Fv \times S1 \dots\dots\dots(8)$$

$$= \left(\frac{2}{3}\right) \times 1,5 \times 0,5841 = 0,5841$$

Structural Analysis

SAP2000 is a very useful software in the field of civil engineering, especially for structural analysis and design. One of its main features is the ability to display analysis results automatically based on the given load data. Users can model the structure, apply different types of loads, such as dead, live, wind, and earthquake loads, and then run the analysis. SAP2000 will calculate the response of the structure, including forces such as moment, torque, and deflection, which are presented in tables and graphs for easy interpretation (Rafi et al., 2020).

The results of the analysis obtained from SAP2000 provide a visual picture of whether or not the analyzed structure is safe or not, as seen in Figure 4.

**Figure 6.** Results of SAP2000 Analysis

The SAP2000 analysis results show that there are errors in the front, rear, and side regel sections, which are marked with a ratio > 1 and represented by red. Blue or green indicates safe conditions (0%-80%), yellow or orange indicates the element is approaching maximum capacity (80%-100%), while red means the element exceeds design limits (>100%) and needs to be strengthened. Colors are also used for stress and deformation analysis, where blue indicates small stresses or displacements, while red signifies the risk of failure. If many elements are red, design modifications such as enlarging the profile or adding bracing are required to keep the structure

safe. The failure to withstand lateral loads causes this fault. To solve this problem, there are two solutions that can be applied: replace the profile with a larger size or add strength to the profile by adding stiffeners. In this case, the chosen solution is to add stiffeners to the steel profile in the middle of the span to improve its stability. Figure 7 displays the analysis results following the enhancement.

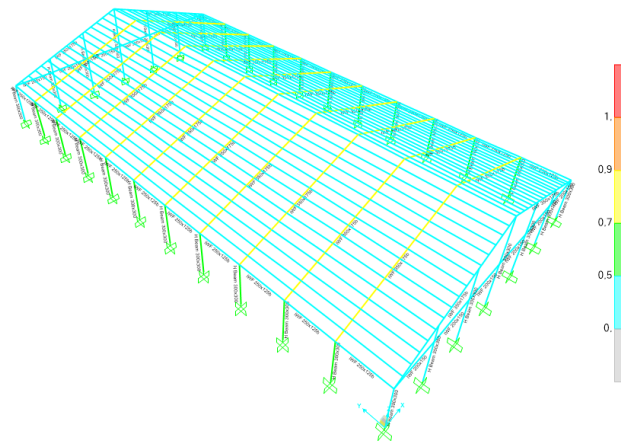


Figure 7. Results of SAP2000 analysis after improvement

Steel Stress Check on SAP2000 is a feature to analyze the stress on steel structural elements based on design standards such as AISC, Eurocode, or SNI. This feature ensures that the steel elements work according to the capacity of the material and meet the planning standards. Its main functions include the evaluation of tensile, compressive, flexural, and shear stresses, as well as stability analysis, such as buckling. It also helps identify design ineligible elements and provides optimization solutions, such as changing profiles or adding curbs. The results of the analysis are presented in a detailed report, making it easy to verify and ensure a safe, efficient, and compliant steel structure design. Figures 8, 9, and 10 display the Steel Stress Check on the superstructure's design.

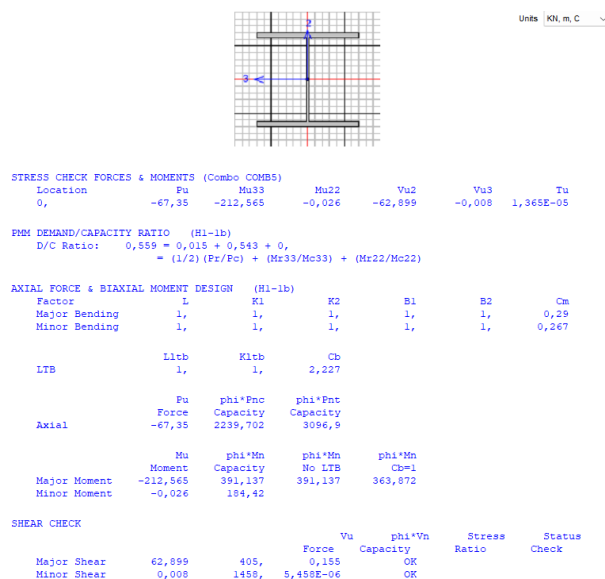


Figure 8. Steel Stress Check On Column

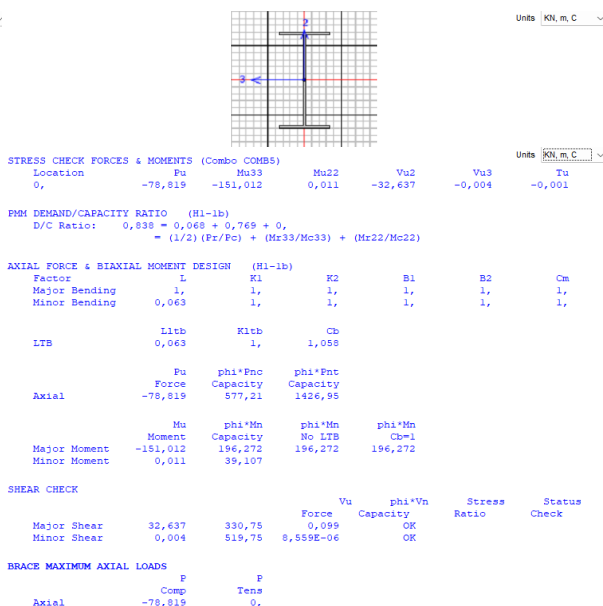


Figure 9. Steel Stress Check On Rafter

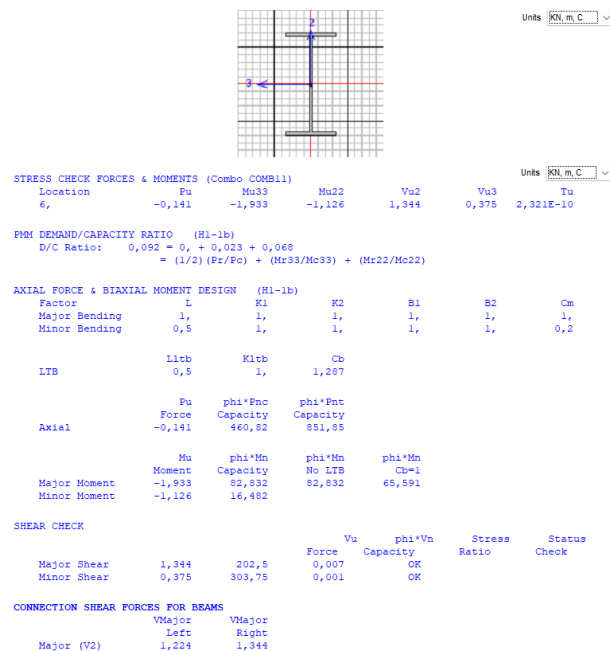


Figure 10. Steel Stress Check On Side Regel

CONCLUSION

The results of the structural planning analysis of the Bantul Regency BPBD logistics warehouse using SAP2000 software show several important findings that increase earthquake resistance. The steel profiles used in the planning of the logistics warehouse top structure consist of IWF 350x175x11x7 rafters, IWF 200x150x9x6 front and rear regels, IWF 250x125x9x6 side regels, as well as HB 300x300x18x10 columns. However, there are faults in the side and front regel structures caused by instability due to failure to withstand lateral loads. Still, the frame on the top of the logistics warehouse does a great job of supporting the weight that it holds, as shown by the safe results of the design of the structure check and the Steel Stress Check on SAP2000 software.

Suggestion

It's necessary to add stiffeners in the middle of the span because the side and front rails on the upper structure of the logistics warehouse aren't stable because they can't handle lateral loads. This means that more research needs to be done on the topic of instability due to failure to handle lateral loads and the need for stiffeners on the frame.

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