ANALYSIS OF STEEL COLUMN MODELING IN CONSTRUCTION FOR BOILER WAREHOUSE EXPANSION BASED ON SAP SOFTWARE

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ABSTRACT: The superstructure is all components that are above the ground. The function of the superstructure is as a support for the building with an upward elongated shape, such as frames, trusses, beams, and columns. The column is a vertical compression member of the structural frame that carries the load from the beam. The construction of this warehouse is located in Tanjung Morawa using IWF steel columns. In this study, the strength of the steel columns was analyzed by modeling using SAP 2000 V.14 and manually calculated on the F portal using the LRFD (Load and Resistance Factor Design) method. The research method uses primary data, namely direct field observations in the form of interviews, and secondary data, namely data taken from the contractor in the form of pictures or from books, previous research, and so on. Based on the results of structural modeling using SAP 2000 V.14, it was concluded that the building is safe; on manual analysis on the F portal, it can be concluded that the steel columns WF-300×150×9×13 and WF-350×175×7×11 are capable of carrying factored compressive loads.

KEY WORDS: IWF Steel, Column, LRFD Method

1. INTRODUCTION

The ideal construction development should be able to review the building first as a drawing from the planning to match the standards, especially on security, safety, and comfort in building buildings. [1]. Building construction must have a structure that supports it. A complete building certainly has various complementary structures to form a perfect building [2]. Construction for building structures is generally divided into two types, the upper and the lower structures. Components in the above-ground structural area are known as superstructures that support buildings with an upward elongated shape, such as frames, trusses, and beams. In comparison, the substructure is a component in direct contact with the ground surface [2], [3]. In addition, this component serves to maintain balance and carry the load on it. The structure of this section must contain the foundation and basement structure. Then the column, a vertical compression member of the structural frame, carries the load from the beam. The column is a compressive structural element that plays an important role in a building. A problem at a critical location can cause the collapse of the relevant floor and the entire structure's total collapse. SK SNI T defines a column as a building structural component whose main task is to support vertical compressive axial loads with a high part that is not supported by at least three times the smallest lateral dimension. The function of the column is to carry the load of the entire building to the foundation [4]–[6]. If compared, the column is like a frame, and the type of building structure, conditions, and elements up to the components that must be in it. Because in the development process, there must be a human body that ensures a building stand. Columns include the main structure to carry the weight of the building and other loads such as live loads (people and goods), as well as wind loads [7], [8].

Columns have a very important function so that buildings do not collapse easily, and a building load starts from the roof [9], [10]. The roof load will transmit the load it receives to the column. All loads received by the column are transferred to the ground surface under the base plate, and then the plate between the steel column and the boat is generally made of concrete. The base plate transmits the load from the column to the foundation and levels the column load that occurs. Making buildings using steel columns must be based on stability calculations and safety factors because mistakes can be fatal, namely loss of property and life.

2. MATERIAL AND METHODS

Research at this location is projected to be a boiler-warehouse expansion construction project using SAP software. To obtain data that follows the problem under study or to be discussed, the researcher uses the following data collection techniques:

2.1 Primary Data

The data collection method used is field observation and data collection in field documentation so that you can find out the real conditions directly in the field regarding what has been done and know the existing condition of the steel column.

2.2. Secondary Data

Data or images obtained from contractors and related agencies that handle construction projects for boiler warehouse expansion using SAP software simulations. Then the researcher collected the following data (a) Literary techniques, namely by obtaining information and data regarding theories related to the subject matter obtained from literature, lecture materials, construction magazines, internet media and other print media. Then (b) Secondary data collection is carried out by collecting steel profile data to complete the data to be analyzed. This steel profile data is needed to find out the profile and size of the steel column, so it is very helpful when analyzing calculations later.

2.3. Data Collection

Before modeling, data collection should be carried out first so the data obtained is more accurate. The author collects data on a primary basis, where the author directs the field. As for collecting data and information on the Boiler Warehouse building in North Sumatra, the results included (a) Drawings of the Boiler Warehouse project plan and (b) Dimensional drawings of Boiler Warehouse Columns and Beams in the city of Medan. Image data was obtained, used for building structure modeling, and then analyzed using SAP 2000 V.14 software with the LRFD (Load And Resistance Factor Design) method.

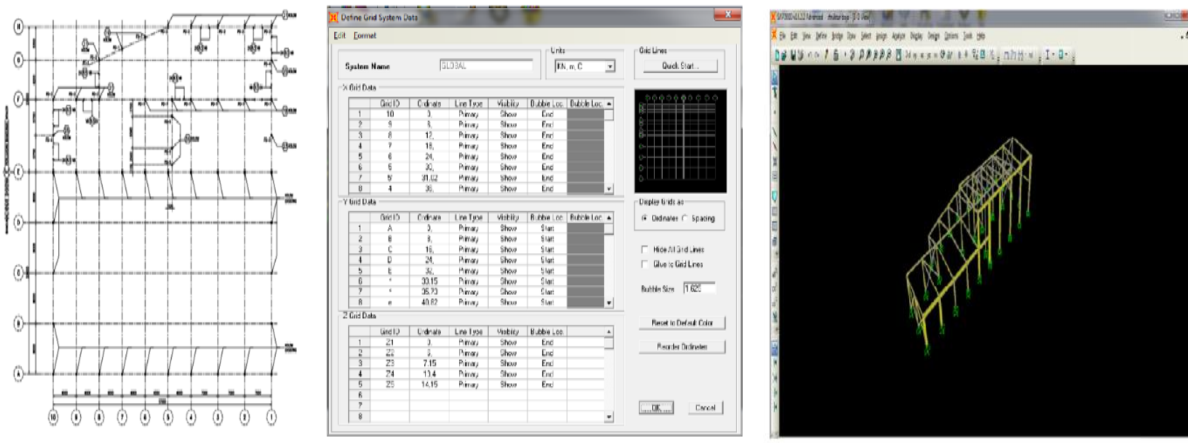
2.4. Stages of Analysis

The stages for analyzing the construction of the boiler warehouse expansion building using SAP software include (a) Collecting structural data, (b) Calculation of structural loading including (live loads, dead loads, wind loads, and rainwater loads), (c) Modeling the warehouse structure using the SAP 2000 V.14 program, (d) Structural analysis on the F portal using the LRFD (Load Resistance Factor Design) method and concluding the results of the analysis.

3. RESULTS AND DISCUSSION

3.1. Modeling Using SAP 2000 V.14

Modeling steel columns in the boiler shed for the project building plan uses SAP 2000 V.14 software with the resulting building height in the main building of 7,150 and the Boiler Machine Warehouse of 14,150. Building plan design simulation, grid and ordinate, and 3-dimensional structural modeling that will be designed using SAP software can be seen in fig 1 below.



(a) (b) (c)

Fig 1. Boiler Warehouse construction design simulation using SAP software consists of: (a) Building plans, (b) Grid and ordinate, and (c) 3-dimensional structural modeling

3.2. Steel Column Data

Dimensions Modeling of steel columns in the boiler shed from the results of the project building plans using the SAP 2000 V.14 software is shown in Table 1.

Table 1: Steel column dimensions

No.	Profil	Simbol
19	WF-350×175×7×11	PD-1
21	WF-300×150×6,5×9	PD-2
23	WF-250×125×6×9	PD-3
25	WF-200×100×5,5×8	PD-4
34	H-200×200×8×12	PD-5

3.3. Calculation of Loads on Building Structures

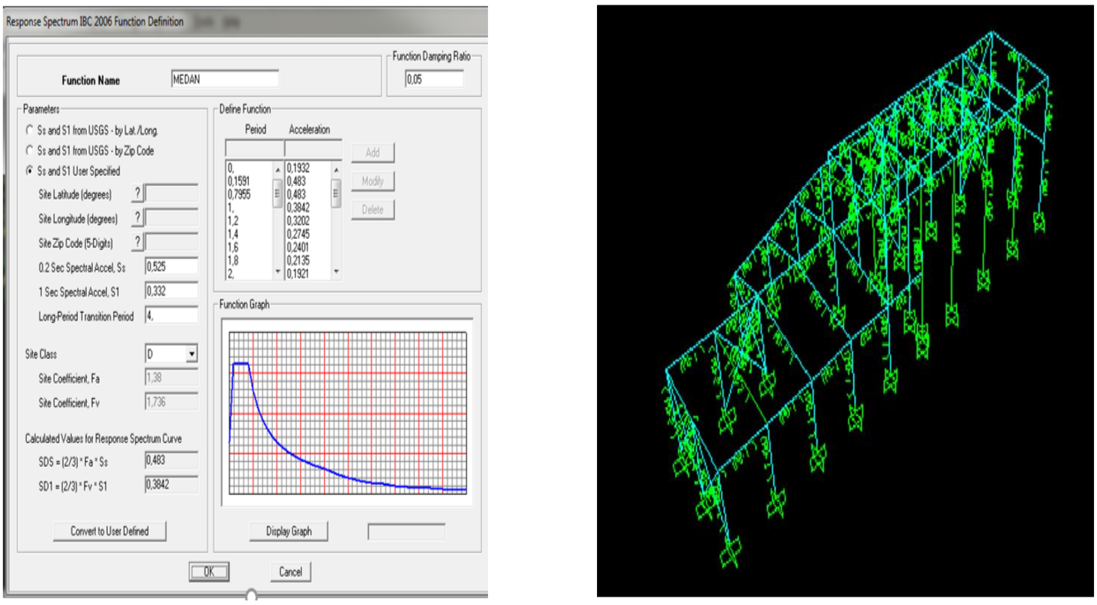
The calculation of loading on the structure is calculated manually as a result of using the SAP 2000 V.14 software. The SAP software can be seen in Table 2 below.

Based on Table 2, the weight of the building can be seen in the calculation. There is an analysis of the roof structure. The calculation of the roof frame structure is divided into several calculations, namely (a) Gording calculation, (b) Calculation of steel truss profiles, and (c)

Loading. Then the earthquake load and the results of the structure check using the Sap 2000 V.14 program are obtained in Fig. 2 as follows.

Table 2: Load calculation results

Load Name	Weight (kg)
Dead Load (D)	40,814 kg
Live Load (L)	100 kg
Wind Load (H)	25 kg
Rainwater Load (H)	24 kg



(a) (b)

Fig 2. Results of the simulation (a) Earthquake loads using the Sap 2000 V.14 program, (b) Results of structural checks on Sap 2000 V.14

3.4. Calculation of Column Strength

Column strength calculations are manually taken on portal F because portal F is the part that bears the biggest load on the building, as shown in Fig. 3.

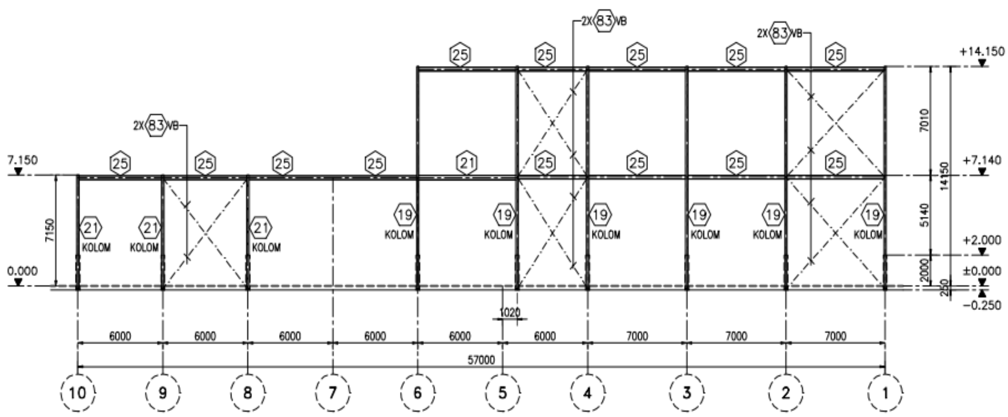


Fig 3. Portal F

Slenderness of the Cross Section

Column WF-350×175×7×11

Flens $\frac{b/2}{tf} = \frac{175/2}{11}$ = 7,954

λr = $\frac{250}{\sqrt{fy}} = \frac{250}{\sqrt{240}}$ = 16,139

λ < λr → 7,954< 16,139 (compact cross-section)

Web $\frac{h}{t_w} = \frac{300}{7}$ = 42,857

λr = $\frac{665}{\sqrt{fy}} = \frac{655}{\sqrt{240}}$ = 42,930

λ < λr → 742,857 < 42,930 (compact cross-section)

Column WF-300×150×9×13

Flens $\frac{b/2}{tf} = \frac{150/2}{13}$ = 5,769

λr = $\frac{250}{\sqrt{fy}} = \frac{250}{\sqrt{240}}$ = 16,139

λ < λr → 5,769 < 16,139 (compact cross-section)

Web $\frac{h}{t_w} = \frac{248}{9}$ = 27,555

λr = $\frac{665}{\sqrt{fy}} = \frac{655}{\sqrt{240}}$ = 42,930

λ < λr → 27,555 < 42,930 (compact cross-section)

Column WF-250×125×6×9

Flens $\frac{b/2}{tf} = \frac{125/2}{9}$ = 6,944

λr = $\frac{250}{\sqrt{fy}} = \frac{250}{\sqrt{240}}$ = 16,139

λ < λr → 6,944 < 16,139 (compact cross-section)

Web $\frac{h}{t_w} = \frac{208}{6}$ = 34,66

λr = $\frac{665}{\sqrt{fy}} = \frac{655}{\sqrt{240}}$ = 42,930

λ < λr → 34,66 < 42,930 (compact cross-section)

Column WF-200×100×5,5×8

Flens $\frac{b/2}{tf} = \frac{100/2}{8}$ = 6,25

λr = $\frac{250}{\sqrt{fy}} = \frac{250}{\sqrt{240}}$ = 16,139 λ < λr → 6,25 < 16,139 (compact cross-section)

Web $\frac{h}{t_w} = \frac{162}{5,5} = 29,454$

$\lambda r = \frac{665}{\sqrt{fy}} = \frac{655}{\sqrt{240}} = 42,930$

λ < λr → 29,454 < 42,930 (compact cross-section)

Column H-200×200×8×12

Flens $\frac{b/2}{tf} = \frac{200/2}{12} = 8,333$

$\lambda r = \frac{250}{\sqrt{fy}} = \frac{250}{\sqrt{240}} = 16,139$

λ < λr → 8,333 < 16,139 (compact cross-section)

Web $\frac{h}{t_w} = \frac{150}{8} = 18,75$

$\lambda r = \frac{665}{\sqrt{fy}} = \frac{655}{\sqrt{240}} = 42,930$

λ < λr → 18,75 < 42,930 (compact cross-section)

Column action:

Table 3: Rated Load (Maximum Combination)

Column Load (Maximum Combination)	**Column Load Data**	
Axial force due to factored loads	N_U =	4389,56 kg
Moment due to factored load	M_U =	2416,80 kg
Shear force due to a factored load	V_U =	971,374 kg

Column Composed Press Structure

WF-300×150×6,5×9

The condition of the clamps, K = 0,65

Ag = 4678 mm^2 (From the steel table)

r_x = 1240 mm

r_y = 329 mm

L_x = 7150 mm

L_y = 7150 mm

Nu = 2,546 ton

E = 200.000 Mpa

Strong axis direction (X axis)

$\lambda x = \frac{K \cdot Lx}{rx} = \frac{0,65 \times 7.150}{1240} = 3,747$

$\lambda cx \quad = \frac{\lambda x}{\pi} \sqrt{\frac{fy}{E}} = \frac{3,747}{3,14} \sqrt{\frac{240}{200.000}} = 0,041$

$0,25 < \lambda cx < 1,2 \rightarrow wx = \frac{1,43}{1,6 - 0,67\ \lambda cx}$

$wx \quad = \frac{1,43}{1,6 - (0,67 \times 0,413)} \quad = \frac{1,43}{1,6 - 0,27} = \frac{1,43}{1,33} = 1,0751$

Nn= $Ag \cdot \frac{fy}{wx}$=4678· $\frac{240}{1,0751}$= 4678· 223,23= 104,426 ton

$\frac{Nu}{\Phi c \cdot Nn} = \frac{2,546}{0,85 \times 104,426}$= 0,02 < 1→ OKE

Weak axis direction (y-axis):

$\lambda y = \frac{K \cdot Ly}{ry} = \frac{0,65 \times 7.150}{329} = 14,126$

$\lambda cy \ = \frac{\lambda x}{\pi} \sqrt{\frac{fy}{E}} = \frac{14,126}{3,14} \sqrt{\frac{240}{200.000}} = 0,155$

$0,25 < \lambda cy < 1,2 \rightarrow wy = \frac{1,43}{1,6 - 0,67\ \lambda cx}$

$wy = \frac{1,43}{1,6 - (0,67 \times 0,155)} \quad = 0,955$

Nn = Ag·fcr = $Ag \cdot \frac{fy}{wy}$ = 4678· $\frac{240}{0,955}$= 117,56 ton

$\frac{Nu}{\Phi c \cdot Nn} = \frac{2,546}{0,85 \times 117,56}$= 0,025 < 1 → OKE

So, the WF-300×150×6.5×9 profile is sufficient to carry a factored compressive load of 2,546 tons.

WF-350×175×7×11

The condition of the clamps, K = 0,65

Ag = 6314 m^2 (From the steel table)

r_x = 1470 mm

r_y = 395 mm

L_x = 14150 mm

L_y = 14150 mm

E = 200.000 Mpa

Nu = 4,389 ton

Strong axis direction (x-axis):

$\lambda x \quad = \frac{K \cdot Lx}{rx} = \frac{0,65 \times 14150}{1470} = 6,256$

$\lambda cx = \frac{\lambda x}{\pi}\sqrt{\frac{fy}{E}} = \frac{6,256}{3,14}\sqrt{\frac{240}{200.000}} = 1,992\sqrt{0,0012} = 0,069$

$0,25 < \lambda cx < 1,2 \rightarrow wx = \frac{1,43}{1,6-0,67\,\lambda cx}$

$wx = \frac{1,43}{1,6-(0,67\times 0,069)} = \frac{1,43}{1,553} = 0,920$

$Nn = Ag\cdot Fcr = Ag\cdot\frac{fy}{wx} = 6314\cdot\frac{240}{0,920} = 164,713$ ton

$\frac{Nu}{\Phi c\cdot Nn} = \frac{4,389}{0,85\times 164,713} = 0,031 < 1 \rightarrow$ OKE

Weak axis direction (y-axis):

$\lambda y = \frac{K\cdot Ly}{ry} = \frac{0,65\times 14150}{395} = 23,28$

$\lambda cy = \frac{\lambda x}{\pi}\sqrt{\frac{fy}{E}} = \frac{23,28}{3,14}\sqrt{\frac{240}{200.000}} = 7,414\sqrt{0,0012} = 0,256$

$0,25 < \lambda cy < 1,2 \rightarrow wy = \frac{1,43}{1,6-0,67\,\lambda cx}$

$wy = \frac{1,43}{1,6-(0,67\times 0,256)} = 1,001$

$Nn = Ag\cdot fcr = Ag\cdot\frac{fy}{wy} = 6314\cdot\frac{240}{1,001} = 151,38$ ton

$\frac{Nu}{\Phi c\cdot Nn} = \frac{4,389}{0,85\times 151,38} = 0,0341 < 1 \rightarrow$ OKE

So, the WF-350×175×7×11 profile is sufficient to carry a factored compressive load of 4,389 tonnes.

4. CONCLUSION

After analyzing steel columns in the simulation construction of boiler shed expansion, it can be concluded that Boiler Warehouse Construction is safer after modeling with SAP 2000 Version 14 with Blue results and some columns are green, indicating the building is safe. The column experiencing the greatest internal forces is in frame F with the axial force due to factored load N_U = 4389.56 kg, moment due to factored load M_U = 2416.80 kg, and shear due to factored load V_U = 971.374 kg. While manual structural analysis on the F frame with steel profiles WF-300×150×6.5×9 is safe to carry a factored compressive load of 2.546 tons, and WF-350×175×7×11 is safe to carry a factored compressive load of 4.389 tons.

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